APPENDIX I

EXAMPLE CALCULATIONS

FLOW RATE AND MOISTURE CALCULATIONS (Dryer Run 1 - 5/13/09)

1 Volume of Dry Gas Sampled at Standard Conditions, dscf

$$V_{mstd} = Y \times V_m \times \frac{(P_{Br} + \Delta H / 13.6) \times (460 + t_{std})}{P_{std} \times [460 + (t_{m1} + t_{m2})/2]}$$

$$V_{mstd} = 1.000 \times 51.816 \times \frac{(30.600 + 1.700 / 13.6) \times (460 + 68)}{29.92 \times [460 + (102 + 92)/2]} = 50.417$$

2 Volume of Water Vapor at Standard Conditions, scf

$$V_{wstd} = 0.04707 \times V_{lc}$$

$$V_{wstd} = 0.04707 \times 40.0 = 1.88$$

3 Percent Moisture, By Volume, as measured in Flue Gas, %

$$\% H_2O = 100 \times V_{wstd} / (V_{wstd} + V_{mstd})$$

$$\% H_2O = 100 \times 1.8828 / (1.8828 + 50.42) = 3.60$$ Used

4 Absolute Flue Gas Pressure, Inches of Mercury

$$P_s = P_{Br} + P_g / 13.6$$

$$P_s = 30.60 + -0.97 / 13.6 = 30.53$$

5 Percent Moisture Saturation at Flue Gas Conditions, %

$$\% H_2O_{sat} = (10^{(6.6911-(3144/(ts+390.86)))}) \times 100 / P_s$$

$$\% H_2O_{sat} = (10^{(6.6911-(3144/(143+390.86)))}) \times 100 / 30.53 = 20.6$$ Used Measured

6 Dry Mole Fraction of Flue Gas

$$M_{fd} = 1 - (\% H_2O / 100)$$

$$M_{fd} = 1 - (3.60 / 100) = 0.964$$

7 Dry Molecular Weight of Flue Gas, lb/lb-mole

$$M_d = 44 \times \%CO_2 / 100 + 32 \times \%O_2 / 100 + 28 \times (100 - \%CO_2 - \%O_2) / 100$$

$$M_d = 44 \times 0.3 / 100 + 32 \times 20.2 / 100 + 28 \times (100 - 0.3 - 20.2) / 100 = 28.86$$

8 Wet Molecular Weight of the Flue Gas, lb/lb-mole

$$M_s = M_d \times M_{fd} + 18 \times \% H_2O / 100$$

$$M_s = 28.86 \times 0.964 + 18 \times 3.60 / 100 = 28.47$$

9 Average Flue Gas Velocity, ft/sec

$$v_s = 85.49 \times C_p \times [(460 + t_s) \times \Delta P_{avg} / (P_s \times M_s)]^{0.5}$$

$$v_s = 85.49 \times 0.84 \times [(460 + 143) \times 0.424 /(30.53 * 28.465)]^{0.5} = 38.95$$

10 Dry Volumetric Flue Gas Flow Rate at Standard Conditions, dscfm

$$Q_{sd} = \frac{60 \times M_{fd} \times (t_{std} + 460) \times P_s \times v_s \times A_s}{(t_s + 460) \times P_{std}}$$

$$Q_{sd} = \frac{60 \times 0.964 \times (68 + 460) \times 30.53 \times 39.0 \times 3.14}{(143 + 460) \times 29.92} = 6{,}326$$

11 Volumetric Flue Gas Flow Rate at Standard Conditions, scfm

$$Q_{scfm} = Q_{sd} \times (100/(100-\%Moisture))$$

$$Q_{scfm} = 6{,}326 \times 100/(100-3.60) = 6563$$

12 Actual Wet Volumetric Flue Gas Flow Rate at Actual Conditions, acfm

$$Q_{aw} = 60 \times v_s \times A_s$$

$$Q_{aw} = 60 \times 39.0 \times 3.14 = 7{,}342$$

VOC RESPONSE FACTOR CALCULATIONS (Dryer 5-13-09)

13 Volatile Organic Compound (VOC - as carbon) Emission Rate, Pounds per Hour (Method 25A)

$$VOC_{lb/hr} = VOC_{ppm} \times \text{MW of carbon} \times Q_{scfm} \times (2.59E-09) \times 60$$

$$VOC_{lb/hr} = 697.70 \times 12 \times 6357 \times (2.59E-09) \times 60 = 8.27$$

VOC_{ppm} = the average VOC concentration measured during two dryer loads (loads 1 and 2)

The average volumetric flowrate for all runs has been used to calculate the lb/hr emission rate

14 Total Gaseous Non-Methane Organic (TGNMO) Emission Rate, Pounds per Hour (Method 25)

$$TGNMO_{lb/hr} = TGNMO_{ppm} \times \text{MW of carbon} \times Q_{scfm} \times (2.59E-09) \times 60$$

$$TGNMO_{lb/hr} = 728 \times 12 \times 6357 \times (2.59E-09) \times 60 = 8.63$$

$TGNMO_{ppm}$ = the average TGNMO concentration measured during two dryer loads (loads 1 and 2)

The average volumetric flowrate for all runs has been used to calculate the lb/hr emission rate

15 VOC / TGNMO Response Factor (RF)

$$RF = TGNMO_{lb/hr} / VOC_{lb/hr}$$

$$RF = 8.63/8.27 = 1.043$$

The response factor is the ratio of Method 25 TGNMO emission rate to the Method 25A VOC emission rate.

VOC EMISSION RATES CALCULATIONS (Dryer 5-13-09)

16 Average VOC (as carbon) Emission Rate, Pounds per Hour

$VOC_{lb/hr}$ = Ave VOC_{ppm} x MW of carbon x Q_{scfm} x (2.59E-09) x 60 x RF (from Equation 15)

$VOC_{lb/hr}$ = 568.00 x 12 x 6357 x (2.59E-09) x 60 x 1.043 = 7.03

VOC_{ppm} = the average THC concentration measured during twelve dryer loads

The average volumetric flowrate for all runs has been used to calculate the lb/hr emission rate

17 Total VOC (as carbon) Emitted during Test Period, Pounds

VOC_{lb} = Ave $VOC_{lb/hr}$ x Emission Period Duration (hours)

VOC_{lb} = 7.03 x 6.27 = 44.0

The duration of the emission test period is the total time that the dryers were in operation during the 12 dryer loads

18 VOC Emission Factor, Pounds VOC per 1000 pounds of Towels

VOC_{lb}/1000 lbs of Towels = Total VOC_{lb} / Total Towel Weight x 1000

VOC_{lb}/1000 lbs of Towels = 44.0 / 6660 x 1000 = 6.61

Total Towel weight (soiled) of 12 wash loads

19 Total VOC Emission Factor (combined sources), Pounds VOC per 1000 pounds of Towels

The total VOC emission factor (lb/1000 lbs of towels) is the sum of the individual emission factors for each source.

Total VOC Emission Factor in pounds of VOC per 1000 pounds of soiled towels

Source	VOC Emission Factor (lb/1000lb)
Towel Wash Room	2.4
EQ Tanks	0.354
Dryer (on)	6.61
Hot Water Heater (on)	0.002
Dryer (off)	0.136
Hot Water Heater (off)	0.026
Total	9.5

20 Annual VOC Emissions from Shop Towels, tpy (Using 2008 Production Data)

Annual VOC emissions are calculated as the product of the emission factor and the soiled weight of shop towels processed.

$VOC_{tons/year}$ = Soiled Weight of Shop Towels Processed (lb) x VOC Emission Factor (lb/1000lb) / (2000 lb/ton)

$VOC_{tons/year}$ = 903,831 lb Shop Towels Processed in 2008 x (9.5 lb VOC / 1000 lb towels) / (2000 lb/ton) = 4.3

HAP (AND RTAP) EMISSION CALCULATIONS (Dryer 5-13-09)

21 TO-15 Hazardous Air Pollutant (HAP) Emission Rates, lb/hr

$$\text{Target Compound}_{lb/hr} = \text{Target Compound}_{ppm} \times \text{MW of Target Compound} \times Q_{scfm} \times (2.59E\text{-}09) \times 60$$

$$\text{Tetrachoroethene}_{lb/hr} = 1.7 \times 165.83 \times 6357 \times (2.59E\text{-}09) \times 60$$

$$\text{Tetrachoroethene}_{lb/hr} = 2.8E\text{-}01$$

22 Total HAPs, lb/hr

Total HAPS (lb/hr) is the sum of the individual HAPs (lb/hr) measured by TO-15. HAPs are identified on the TO-15 summary page with an H.

The average HAP emission rate from the Dryer (during processing of shop towels) was 0.36 lb/hr

23 Total HAPs Emitted during Test Period, Pounds

$$HAP_{lb} = \text{Ave } HAP_{lb/hr} \times \text{Emission Period Duration (hours)}$$

$$HAP_{lb} = 0.36 \times 6.27 = 2.26$$

The duration of the emission test period is the total time that the dryers were in operation during the 12 dryer loads

24 HAP Emission Factor, Pounds HAP per 1000 pounds of Towels

$$HAP_{lb}/1000 \text{ lbs of Towels} = \text{Total } HAP_{lb} \;/\; \text{Total Towel Weight} \times 1000$$

$$HAP_{lb}/1000 \text{ lbs of Towels} = 2.26 \;/\; 6660 \times 1000 = 0.339$$

Total Towel weight (soiled) of 12 wash loads

25 Total HAP Emission Factor (combined sources), Pounds HAP per 1000 pounds of Towels

The total HAP emission factor (lb/1000 lbs of towels) is the sum of the individual emission factors for each source.

Total HAP Emission Factor in pounds of VOC per 1000 pounds of soiled towels

Source	HAP Emission Factor (lb/1000lb)
Towel Wash Room	0.62
EQ Tanks	0.045
Dryer (on)	0.34
Hot Water Heater (on)	0.0005
Dryer (off)	0.035
Hot Water Heater (off)	0.007
Total	1.0

26 Annual HAP Emissions from Shop Towels, tpy (Using 2008 Production Data)

Annual HAP emissions are calculated as the product of the emission factor and the soiled weight of shop towels processed.

$HAP_{tons/year}$ = Soiled Weight of Shop Towels Processed (lb) x HAP Emission Factor (lb/1000lb) / (2000 lb/ton)

$HAP_{tons/year}$ = 903,831 lb Shop Towels Processed in 2008 x (1.1 lb HAP / 1000 lb towels) / (2000 lb/ton) = 0.5

RTAP Ambient Air Limit (AAL) Evaluation (Annual Avg for m,p-Xylene)

27 Annual Average Actual m,p-Xylene Emissions Using TO-15 Data, µg/sec (Shop Towels at Dryer)

m,p-Xylene $_{(\mu g/s\ annual\ avg)}$ = Avg TO-15 m,p-Xylene Emissions (lb/hr) x Operating Hours During Test Day (hr/day) / Weight of Shop Towels during Test Day (lb/day) x Annual Weight of Shop Towels Processed (lb/yr) / 8,760 Calendar Hours per Year / 7.94 grams/second per lb/hr x 1E6 micrograms per gram

= (4.9E-2 + 6.2E-2 / 2 lb/hr) x 6.27 hr/day / 6,660 lb/day x 1,000,000 lb/yr / 8,760 hr/yr / 7.94 x 1E6

= 751 micrograms of m,p-xylene per second

m,p-Xylene Emission Rate for Shop Towels	(µg/s, Annual Avg)
Towel Wash Room	1.13E+03
EQ Tanks	1.99E+02
Dryer (on)	7.51E+02
Hot Water Heater (on)	8.86E-01
Dryer (off)	6.38E+01
Hot Water Heater (off)	1.20E+01
Total:	**2.15E+03**

m,p-Xylene Emission Rate for Print Towels	(µg/s, Annual Avg)
Wash Room (day)	1.24E+04
EQ Tanks (day)	9.24E+02
Dryer (on)	1.57E+04
Hot Water Heater (on)	7.95E+00
Dryer (off)	5.15E+02
Hot Water Heater (off)	1.25E+02
Wash Room (night)	1.14E+03
EQ Tanks (night)	1.11E+03
Total:	**3.20E+04**

28 Annual Average Exhaust Flow Rate, m^3/sec (Shop Towels at Dryer)

Exhaust Flow $_{(cubic\ meters/sec\ annual\ avg)}$ = Dryer Exhaust Flowrate (actual cubic feet / min) x 60 min/hr x Operating Hr During Test (hr/day) x 260 Operating Days per Year [5 days @ 52 weeks] / 8,760 Calendar Hours per Year / 60 min/hr / 2,119 cubic meters/sec per cubic feet/min

= 7200 acfm x 60 min/hr x 6.27 hr/day x 260 day/yr / 8,760 hr/yr / 60 min/hr / 2,119

= 0.63 cubic meters per second

Exhaust Flow Rate for Shop Towel Runs	(cubic meters/sec, Annual Avg)
Towel Wash Room	6.84E-01
EQ Tanks	4.24E-02
Dryer (on)	6.32E-01
Hot Water Heater (on)	4.97E-02
Dryer (off)	2.29E-02
Hot Water Heater (off)	8.83E-02
Total:	**1.44E+00**

Exhaust Flow Rate for Print Towel Runs	(cubic meters/sec, Annual Avg)
Wash Room (day)	7.33E-01
EQ Tanks (day)	4.71E-02
Dryer (on)	2.99E-01
Hot Water Heater (on)	2.32E-02
Dryer (off)	4.67E-02
Hot Water Heater (off)	1.13E-02
Wash Room (night)	5.73E-01
EQ Tanks (night)	6.04E-02
Total:	**1.79E+00**

29 Annual Average Adjusted In-stack Concentration for m,p-Xylene per Env-A 1405.05, µg/m^3

Adj In-stack Conc $_{(ug/m3\ annual\ avg)}$ = (Actual Annual Shop Towel Emissions (µg/sec) / Exhaust Flow Rate (m^3/sec) / 400) + (Actual Annual Print Towel Emissions (µg/sec) / Exhaust Flow Rate (m^3/sec) / 400)

= (2.15E+3 µg/sec / 1.44 m^3/sec / 400)$_{\text{Shop Towels}}$ + (3.20E+4 µg/sec / 1.79 m^3/sec / 400)$_{\text{Print Towels}}$

= 48 ug/m^3